2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Compatibility of low separatrix density and divertor heat load at a JT-60SA H-mode operation scenario using SONIC multi-impurity Monte-Carlo model

H. Kawashima[1], K. Hoshino[2], N. Hayashi[1], T. Nakano[1]
[1] National Institute for Quantum and Radiological Science and Technology (QST),
[2] Keio University
e-mail (speaker): kawashima.hisato@qst.go.jp

As for the H-mode operation scenario ($P_{totalinput}$=41 MW, I_P=5.5 MA, B_T=2.25 T, line averaged electron density n_{e_ave}=6.3x10^{19} m^{-3}, Lower Single Null) in the JT-60SA tokamak [1], the separatrix electron density $n_{e\_mid}^{SOL} \le n_{e\_ave}/3$ = 2.1x10^{19} m^{-3} has been required together with the divertor peak heat load $q_t^{DIV} \le$ 10 MW/m^2. Although higher $n_{e\_mid}^{SOL}$ is preferable for reduction of q_t^{DIV}, Ar impurity seeding helps reduction of q_t^{DIV} in lower $n_{e\_mid}^{SOL}$. Therefore, compatibility of their low $n_{e\_mid}^{SOL}$ and q_t^{DIV} was evaluated and achieved using SONIC MI (multi impurity Monte-Carlo) model [3], considering with impurity behavior of C (intrinsic wall impurity) and Ar (impurity seeding).

The MI model has advantages in the multi impurity transport modelling, such as the thermal force, plasma wall interactions etc. Calculation was started using a steady state solution obtained by the modified coronal radiation model (MCR) [4] to save the calculation time.

Input parameters of D_2 gas puff (Γ_{puff}^{D2}), Ar puff (Γ_{puff}^{Ar}), chemical sputtering yield of C (Y_{chem}^{C}) and divertor pumping speed (S_{pump}) were surveyed for H-mode scenario in the ranges of Γ_{puff}^{D2} =14~58 Pam^3/s, Γ_{puff}^{Ar} =0.3~4.8 Pam^3/s, Y_{chem}^{C} = 0.01~0.03 and S_{pump} = 25~100 m^3/s. Gas puff positions (located 4 ports on JT-60SA) were changed depending on the solutions. Resulting, $n_{e\_mid}^{SOL}$~2.1x10^{19}/m^3 and q_t^{DIV} =8.75 MW/m^2 were able to obtained simultaneously on a set of Γ_{puff}^{D2} =27 Pam^3/s, Γ_{puff}^{Ar} =2.3 Pam^3/s, Y_{chem}^{C} = 0.01 and S_{pump} = 50 m^3/s.

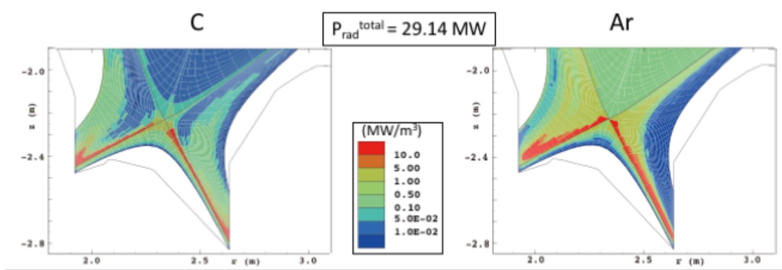
For the impurity behavior, figure 1 shows the 2D profiles of C and Ar radiation power in the lower divertor regions. They are enhanced along the divertor leg. The total radiation power is P_{rad}^{total} ~ 29 MW (radiation fraction = 73% of power from the core). Comparing the contribution of C and Ar radiation in SOL/Div regions (bottom table in the figure 1), Ar radiation is dominated at this condition.

Each ionized Ar density by the MI simulation was distributed in the divertor reflecting with their electron shell structures surrounding nucleus. Lower ionized n_{Ar} (Z=1-7) concentrates along the divertor leg. Middle and highly ionized n_{Ar}(Z=8-15), n_{Ar}(Z=16-18) penetrate toward to high temperature SOL/Core edge regions.

While, there were typical changes in the SOL poloidal profiles of electron density and temperature. The density peaking and the temperature digging were formed in upper SOL and relived gradually along the inner SOL poloidal direction. As following it, the density fraction of C and Ar, and ionized Ar density over middle range were localized in upper to inner SOL regions. It had not been shown by MCR modelling which had almost flat profile. Detailed analysis of the typical results will be studied, considering with the impurity transport.

However, those results gave a concern about affect to the core plasma. Further optimization of the input parameters will also be carried out to avoid above concern.

References
[1] JT-60SA Research Plan (http://www.jt60sa.org/pdfs/JT-60SA_Res_Plan.pdf)
[2] H. Kawashima et al., Plasma Phys. Control. Fusion 49, S77-S85 (2007).
[3] K. Hoshino et al., to be published Contrib. Plasma Phys. (2018).
[4] H. Kawashima et al., Contrib. Plasma Phys. 56, 778-783 (2016).



Regions	Outer Divertor	SOL	Inner Divertor	Core Edge (r/a ≥ 0.95)
P_{rad}^{C} (MW)	2.39	0.32	1.99	0.41
P_{rad}^{Ar} (MW)	8.82	3.63	6.49	3.74

Figure 1 C and Ar radiation power in lower divertor regions by MI simulations.